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(54) **Tyre Beads**

(57) A tyre bead reinforcement comprises a circumferentially inextensible core *c* enclosed in elastomeric material, the material forming the outer surface of the reinforcement having a lower vulcanising speed than the remainder of the elastomeric material in the reinforcement. Semi-vulcanisation of the reinforcement prior to assembly in a tyre results in the material immediately surrounding the core *c* being sufficiently vulcanised to prevent distortion of the core *c* during tyre building while the material constituting the outer surface is still unvulcanised so as to enable satisfactory adhesion of the reinforcement to adjacent components of the tyre during building without any additional treatment of the reinforcement, e.g. application of an adhesive. As illustrated a wire core *c* is surrounded by elastomer 1 surrounded by an elastomer filler 3, the latter being covered by a spirally wound strip of elastomer 2 containing heat shrinkable cords 5 and in turn covered by a layer of elastomer 4. The vulcanising speeds of these components are in the order $1 \geqslant 3 > 2 > 4$.

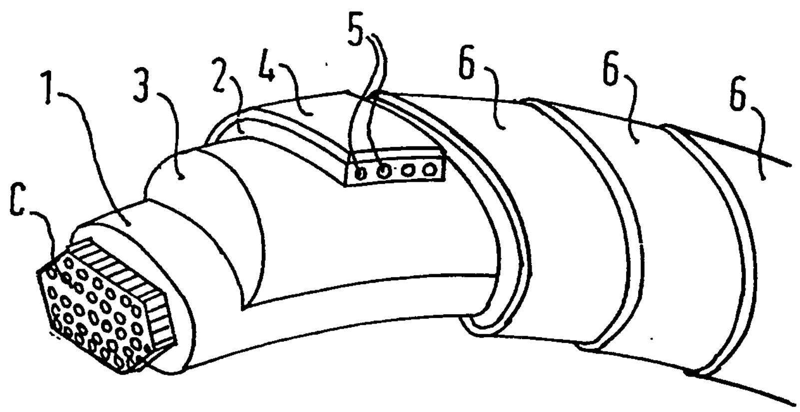

FIG.2

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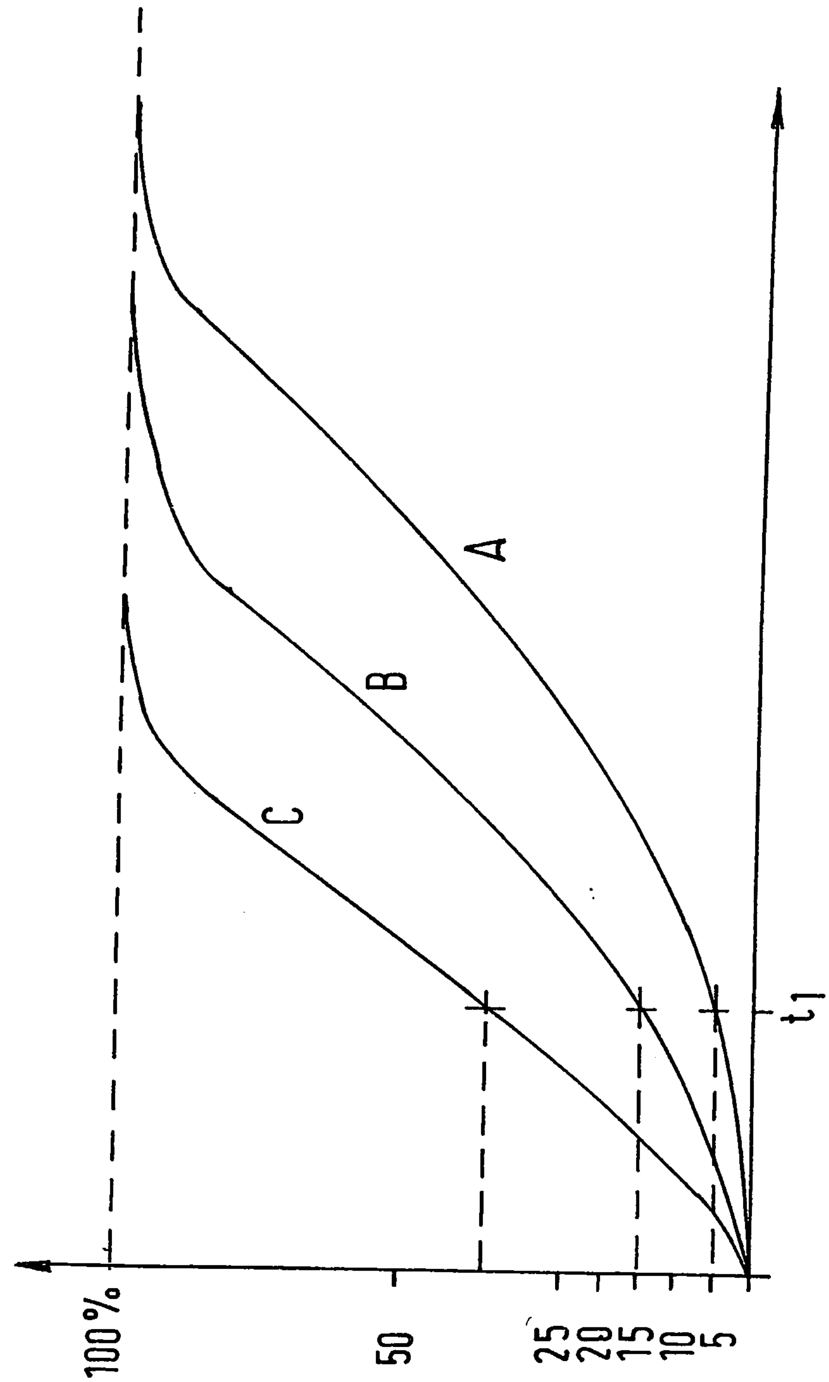

FIG.1

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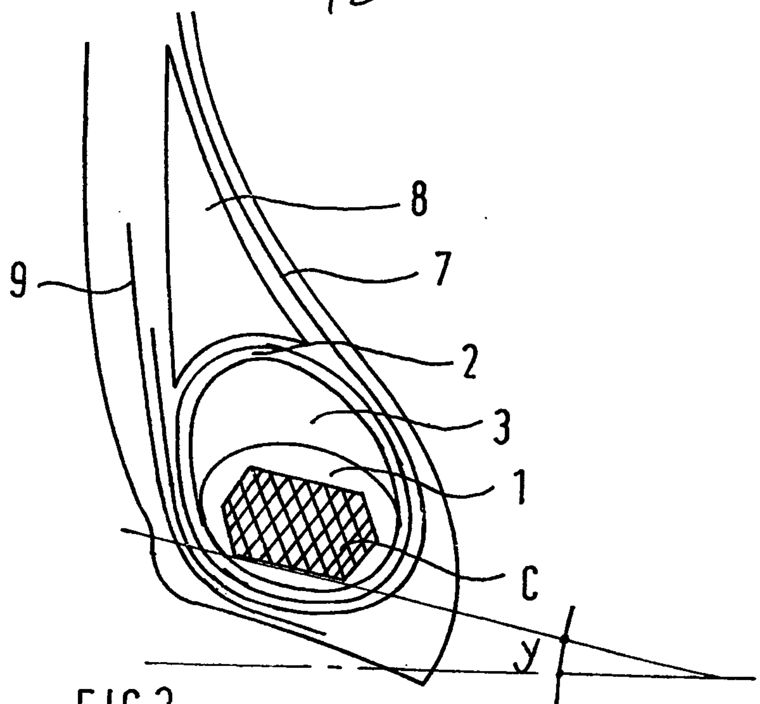

FIG.3

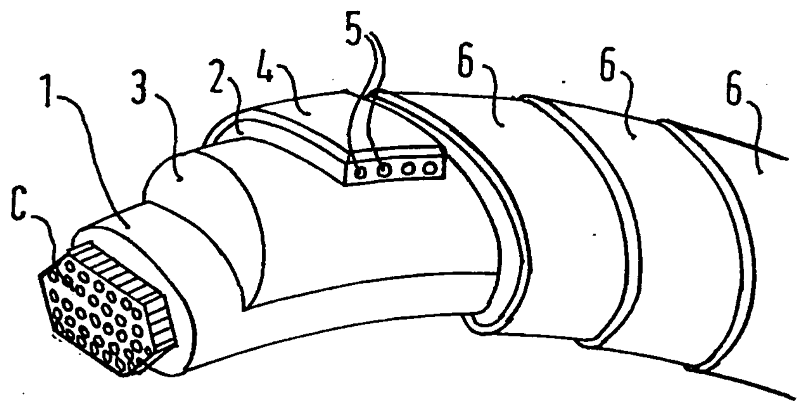

FIG.2

SPECIFICATION

Improvements In Or Relating To Tyres

The present invention concerns improvements in or relating to tyres. More specifically the invention concerns the tyre beads, i.e. the two annular portions at the radially innermost extremity of the carcass which serve for connecting and anchoring the tyre to a matching wheel rim, and in particular the annular bead reinforcements which stiffen and render the beads circumferentially inextensible.

The fundamental importance of tyre bead zone is already well known to any technician of the art. Thus tyre beads in fact condition in a prevailing manner (above all in heavy duty tyres) the road behaviour of the tyre during exercise.

It is commonly known that the tyre beads are usually reinforced with annular circumferentially inextensible metallic bead reinforcements, usually referred to as "bead cores".

A quite common example of a bead core is that constituted by a plurality of adjacent coils of rubberised metallic wire assembled in a plurality of radially over-lapping layers so as to form an annular pack having a quadrilateral cross-section.

More recently another type of bead core has been developed constituted by a plurality of adjacent coils of metallic wire (automotive tyres) or metal strips (heavy duty tubeless-type tyres) assembled to form an annular pack having a hexagonal cross-section with the radially innermost side of the core inclined at 15° relative to the core axis.

The ends of the carcass ply or plies must be turned-up around the bead cores in such a way as to be compactly anchored to the bead reinforcements. Only in this way is the carcass capable of resisting the traction forces which are exerted upon the reinforcing cords of the ply or plies by the pressure used for shaping and vulcanising the tyre during the tyre manufacturing process. Sometimes where the core is of hexagonal cross-section this is opportunely rounded off with the aid of suitable rubber strips so as to favour the turning up of the carcass plies around the bead core during the tyre manufacturing process, more precisely during the phase of shaping the tyre.

Nevertheless no matter what the size and the cross-section of the bead cores may be, it is known, especially in the case of bead cores having a polygonal cross-section e.g. the above-described hexagonal bead cores, that the forces acting within the bead zone during the vulcanising phase have the effect of deforming the bead cor 's cross-section. Thus the bead core acquires an irregular shap that is rather rhomb idal resulting in a consequent modification in the global ge m try of the bead z ne with respect to that int nd d.

Many solutions have be n proposed for verc ming this probl m by conferring a transverse rigidity to the b ad core section. Among all f these th proposal which has proved to be particularly ffective is that of taping th bead core with a rubberis d fabric, wound in loops or spirals, along the circumferential development of the bead core and then semi-vulcanising the bead core before using the bead core in the tyre manufacturing process.

This proposal presents, nevertheless, a serious drawback in that the semi-vulcanisation process deprives the exposed elastomeric part of the bead core, i.e. the outer surface of the core's rubberised wire, or that of the outer component, of certain physical, e.g. tackiness, and chemical characteristics of the uncured rubber that are necessary for the adhesion and compacting with the other carcass elements thus rendering the bonding to be more unreliable and difficult, either chemically or physically, between the rubber of the bead core and that of the other components in the bead zone during the remaining part of the manufacturing process. In order to overcome this drawback it is essential to subject the semi-vulcanised bead cores to a further treatment for the purpose of restoring to this semi-finished article at least the necessary physical characteristics of tackiness, the chemical characteristics being no longer restorable.

This extra operation, i.e. a solutioning treatment of the bead cores, constitutes a delicate phase in the tyre manufacturing process due to the deleterious effects in the quality of the finished tyre arising from an unsatisfactory treatment. Also the extra operation incurs an increase in expenditure of both time and money.

The object of the present invention is a new type of bead core for tyre beads which can be semi-vulcanised without the bead core's external surface losing its physical and chemical characteristics whereby the bead core is immediately utilizable after the semi-vulcanising step without requiring any further treatment.

According to the present invention a tyre bead reinforcement comprises an annular circumferentially inextensible bead core completely enclosed in elastomeric material of which the material constituting the outer surface has a vulcanising speed less than that of any other elastomeric material incorporated in the bead reinforcement.

As used herein by vulcanising speed is intended the rapidity with which an elastomeric material passes from its crude uncured state (distinguished by prevailing characteristics of plasticity) to its cured state (distinguished by prevailing characteristics of elasticity). As will be explained in more detail later this change can be identified and monitored through the progressive variations in the value of certain parameters, for example the elasticity m dulus f th elast m ric mat rial in which case th vulcanising spe d can b d fined as being th incr as in th valu of th elasticity m dulus for a giv n time unit.

Preferably, for tubel ss tyres, the bead core is constituted by a plurality of coils of metallic wir arranged adjacent to on another to form a pack having a substantially hexagonal cross-s cti n

with the sid which is radially innermost inclined at about 15° with respect to the core axis.

The core is preferably wrapped in a first layer of elastom ric mat rial having a thickness preferably comprised between 1.5 and 2.0 mm. A second layer constituted by a cord fabric comprising elastomeric material in the form of a strip reinforced with cords extending longitudinally of the strip and made of a material that shrinks under the effects of heat is wound spirally over the first layer and the core along the entire circumferential development of the bead reinforcement. The elastomeric material of the second layer has a lower vulcanising speed than that of the first layer.

Conveniently there is inserted in a radially outer position with respect to the core between the first and second layers a filler having a lentil-shape. The filler, used for compacting, is preferably made of elastomeric material having a vulcanising speed similar to that of the elastomeric material of the first layer.

Preferably the radially outer surface of the second layer is covered by a third layer constituted by a thin sheet of elastomeric material having a lower vulcanising speed than the elastomeric material of the second layer. Preferably the third layer has a thickness comprised between 0.5 and 0.8 mm.

Preferably the elastomeric material of the first layer when subjected to a thermal treatment at a temperature not higher than 120°C for a duration not more than 15 minutes reaches a degree of vulcanisation defined by the variation curve in its elasticity modulus of not less than 20% and preferably not less than 30%.

Preferably the elastomeric material of the third radially innermost layer which, according to the foregoing has a vulcanising speed lower than that of any other elastomeric material incorporated in the bead reinforcement, when subjected to a thermal treatment at a temperature not lower than 120°C for a duration not less than 15 minutes reaches a degree of vulcanisation defined by the variation curve in its elasticity modulus of not more than 15% and preferably not more than 10%.

According to a further aspect of the present invention we provide a pneumatic tyre, preferably tubeless, having a tread connected at opposite edges to a respective one of a pair of sidewalls each of which terminates at its radially innermost edge in a respective tyre bead provided with a bead reinforcement according to the first aspect of the present invention.

The invention will now be described in more detail, by way of example only, with reference to the acc mpanying drawings wherein:

Figure 1 sh ws th vulcanising curv s for three elastomeric mat rials which serv to define th rate of vulcanisati n and the degre of vulcanisation for each material;

Figure 2 shows in perspectiv lateral view (partly cut-away) a tyre bead according t the present invention; and

Figur 3 shows in cross-s ction th b ad zon of a tyre incorporating the tyre bead shown in Figur 2.

Firstly, with the aid of Figure 1, th quantitativ significance of the terms used herein, namely: vulcanisation, semi-vulcanisation, rate of vulcanisation and degree of vulcanisation will be explained.

It is already known that elastomeric materials when subjected to a thermal treatment change some of their physical and chemical characteristics in an irrevocable manner. One type of example is the change of a material from a plastic state (uncured) to an elastic state (vulcanised).

The change in some characteristics can be correlated to the variations in the value of a given parameter for example from a minimum value (assume zero) to a maximum value which in some cases can also be constant i.e. not further modifiable by continuing the applied thermal treatment.

The state reached by an elastomeric material in transformations is therefore defined as the degree of vulcanisation and can be indicated by referring to the variations in the value of the parameter chosen as a guide expressed as a percentage of the time interval between the above-said minimum and maximum values and a given material is defined as being uncured, semi-vulcanised or completely vulcanised depending on the degree of vulcanisation it has reached.

The variations in the value of the parameter chosen to indicate the progress of vulcanisation when plotted on a value-time diagram allow a curved line to be drawn which graphically represents the development of the vulcanisation of the elastomeric material with respect to the time involved.

The slope of the tangent drawn at a point on the curve identifies the vulcanisation speed of the elastomeric material at that point and is expressed mathematically as the ratio between the increase in value of the measured parameter and the time interval over which this increase takes place.

To a first approximation the vulcanising speed depends upon the temperature applied but at a parity of temperature and of other conditions of the thermal treatment depends upon the composition of the elastomeric composition, more particularly upon the type and quantity of those ingredients known as accelerators.

Figure 1 represents the variations in the value of one parameter, more precisely the elasticity modulus, with time for three different elastomeric materials A, B and C. The diagram is illustrated in th following way:

The absolut values of the elasticity modulus, expressed f r example in Megapascal, are defined through methods and instruments alr ady known to technicians skilled in th art which ne d not be further discussed h rein. Once the conditions of thermal treatment hav been established (development of th temperature and of the

v ntual applied pressur — for example a constant temp rature and atmospheric pressure) the elasticity modulus of ach lastomeric material is measured at prefixed time intervals during the thermal treatment. In Figure 1, for convenience sake, in place of the absolute values of the elasticity modulus the percentage values (more significant than the absolute values for the purpose of the present invention enabling the same reading scale to be used for three elastomeric materials thus facilitating the comparison between the three curves) are plotted on the ordinate (Y axis) and the time interval on the abscissa (x-axis) resulting in curves A, B and C. This diagram referred to as a 'vulcanisation curve' represents the development of vulcanisation of the elastomeric materials as a function of the established conditions.

As used in this specification a material is defined as being vulcanised when its degree of vulcanisation exceeds 90% and uncured when its degree of vulcanisation is less than 15%. A material is defined as being semi-vulcanised when its degree of vulcanisation is between these values.

Thus with reference to Figure 1 at the moment in time t, the three elastomeric material A, B and C with the same thermal treatment have reached respective degrees of vulcanisation equal to 5%, 15%, and 37%.

The gradient of the vulcanising curve, i.e. its derivative, defines the vulcanising speed of the elastomeric material, meaning that with a slight gradient (low speed) the time required for obtaining complete vulcanisation (100%) of the elastomeric material is greater than with a steep gradient (high speed) for a given thermal treatment.

Accordingly by altering the composition of the elastomeric material it is possible to obtain materials having different vulcanising speeds in respect of the same thermal treatment. Suitable compositions, once the characteristic of the behaviour desired has been established, will be apparent to those skilled in the art and are not described in detail herein as such compositions do not form an essential part of the invention.

Referring now to Figure 2 there is shown in perspective lateral view (partly cutaway) a bead reinforcement according to the present invention. The reinforcement defined above as a 'bead core' consists of an annular circumferentially inextensible metallic core *c* constituted by a plurality of coils of metallic wire arranged adjacent to one another to form a pack of hexagonal cross-section with the radially innermost side inclined at an angle *y* equal to about 15° with resp ct to the bead axis and hence to the tyre axis. The cor *c* is covered by a first compacting lay r 1 f elastomeric material having a thickn ss of betw n 1.5 and 2.0 mm. The layer 1 in turn is completely enclosed in a second layer 2 of rubberised cord fabric with a filler 3 of lastomeric material having a l ntil cross-section sandwiched between the layers 1 and 2. The layer 2 is constituted by a strip 6 of elastomeric material r inforced with t xtile cords 5 preferably f a material that shrinks under th effects of heat e.g. nylon, extending longitudinally of the strip 6 which is helicoidally wound, each turn side-by-side with the adjoining turn, along the entire circumferential development of the bead core. Finally, the outer surface of the layer 2 is covered with a sheet 4 of elastomeric material having a thickness of between 0.5 and 0.8 mm.

may be excluded

The vulcanising behaviour of the above-described bead reinforcement is determined by the vulcanising speeds of the elastomeric materials incorporated therein which in turn for a given thermal treatment depends upon the composition of the elastomeric materials.

The composition of the elastomeric materials constituting the layers 1 and 2, filler 3 and sheet 4 are all different and are chosen so that the vulcanising speeds of the elastomeric materials are in the order layer 1 $\geqslant$ filler 3 > layer 2 > sheet 4 i.e. constituting the outer surface of the bead reinforcement is made of an elastomeric material having a vulcanising speed less than that of any other elastomeric material incorporated in the bead reinforcement.

More particularly the composition of the elastomeric materials incorporated in the bead reinforcement are chosen so that when subjected to a semi-vulcanisation treatment (time/temperature) prior to incorporation of the reinforcement in the tyre manufacturing process the material immediately surrounding the core *c*, i.e. layer 1, reaches a degree of vulcanisation (expressed with reference to the elasticity modulus of the material) $\geqslant$20% i.e. is semi-vulcanised sufficiently to compact the core *c* into its hexagonal cross-section and render it indeformable during the subsequent tyre manufacturing process while the material constituting the outer surface i.e. sheet 4 reaches a degree of vulcanisation $\leqslant$15% i.e. is still uncured and hence retains all the chemical and physical characteristics necessary for providing a good adhesion and bonding to the other elements in the bead zone during the subsequent tyre manufacturing process. Simultaneously the elastomeric material of the filler 3 reaches a degree of vulcanisation similar to that of the material constituting the layer 1 and the elastomeric material of the layer 2 reaches a degree of vulcanisation intermediate that of the materials constituting layer 1 and sheet 4 respectively.

The lower vulcanising speed for the elastomeric material of layer 2 as compared with that of layer 1 and filler 3 enables the cords 5 of the heat shrinkable material t contract radially inwards and reach a state of tension around th und rlying layer 1 and b ad core *c* whereby th bead core *c* is further compacted improving its resistanc to d formation in th subsequent tyre manufacturing process. The radial contraction of the cords 5 also produces on the external surface of the s mi-vulcanised bead reinforcement a

slightly undulating profile with a helicoidal layout similar to that of a screw thread thereby facilitating th anchoring of the oth r elem nts in the bead zone to the bead reinforc ment in th subsequent tyre manufacturing process.

Figure 3 shows the bead zone of a tyre incorporating the bead reinforcement shown in Figure 2 and a bead filler 8. The carcass plies indicated generally by reference numeral 7 are turned up around the bead reinforcement and one or more reinforcing layers indicated generally by the reference numeral 9 are provided outside the turn-up of the carcass plies.

Although the invention has been described in detail with reference to a particular construction of bead reinforcement it will be understood that various modifications can be made to the construction depending upon the type of annular bead reinforcement specifically required by the type of tyre (car tyre, giant tyre with a textile or metallic carcass for automotive vehicles or for special usages).

For example, in a bead reinforcement having a quadrangular cross-section core of rubberised wire the layer 1 of the above-described bead reinforcement can be constituted by the rubber of the metallic wire, the outermost layer by the rubber sheet 4 or by the rubberised fabric 2 looped around and/or coiled around the core with or without the filler 3.

In the above-described bead reinforcement having a core of metallic (non-rubberised) wire that is enveloped with the rubberised cord fabric 2 covered by the rubber sheet 4 the layer 1 and filler 3 may be omitted.

Alternatively, if a filler 3 is included between the metallic core *c* and the rubberised cord fabric 2, then the layer 1 and the layer 4 can be omitted.

It is clear therefore on the basis of the foregoing description that one skilled in the art will have no difficulty at least from the conceptual point of view in elaborating a suitable practical solution to the proposed problem. Thus the bead reinforcement according to the invention resolves the proposed problem by bringing about further sensible improvements in the qualitative level of the tyre.

In fact, in the first place, the invention has proved a remedy to the intrinsic weakness in the links between the surface of the semi-vulcanised bead reinforcement and that of the other elements in reciprocal contact one with the other in the bead zone.

In the tyres of the state of the art this link is entrusted to only the operation of a solutioning treatment, since the operation of semi-vulcanisation has deprived the covering compound of the c r of its capacity to chemically bind at a molecular level with the comp unds of the other elements in the b ad zone thus creating a zone of separation, almost a fracture, b tw en th b ad reinforcement and adjac nt elements which are r ciprocally "gummed together" by the solutioning liquid of the solutioning treatment only.

In a tyre incorporating th bead reinforcement of th invention this ch mical link is inst ad stablished during the vulcanisation of the tyre owing to the presence of a still uncured composition on the radially outermost surface of the bead reinforcement after the semi-vulcanising treatment whereby the outermost surface of the bead reinforcement is in the same condition as those of the filler and the carcass plies that are also non-vulcanised.

There is thus established a gradual variation in the degree of vulcanisation in the semi-vulcanised bead reinforcement from the outside towards the inside of the reinforcement from a minimum value to a maximum value, probably due to the fact that during the semi-vulcanising treatment a migration occurs of the ingredients of the elastomeric compositions that are in reciprocal contact and in particular those ingredients which are more influential upon the vulcanising speed, from one compound to another, through the contacting surfaces and hence a continuous variation of the characteristics of the compounds in reciprocal contact.

In conclusion in a tyre incorporating the bead reinforcement of the invention the vulcanised bead behaves as a limiting continuous structure and not as two structures (naturally we exaggerate here) adhering together by means of a solutioning treatment in correspondence of the surfaces of reciprocal contact between the bead reinforcement and the adjacent element i.e. filler and carcass plies.

The achievement of this link between the abovesaid elements which go to make up the bead zone results in the optimization of both the form of the bead reinforcement (giving to the bead a larger section) as well as a degree of compactness and stability of the form associated with a degree of semi-vulcanisation which is quite high, a fact which is unfeasible in the tyres of the state of the art.

In fact, the increase in the surface area, resulting from the increased volume of the bead reinforcement, does not have any further negative influence upon the quality of the tyre bead, thanks to the abovesaid excellent adhesion between the elements in the bead zone, while the greater indeformability of the semi-vulcanised bead reinforcement during the vulcanising process of the tyre coupled with the greater volume of the bead reinforcement has permitted the profile of the carcass plies and of the reinforcing layers around the said bead to be modified thus unloading the cords of the fabrics from those tensional concentrations present in the tyres of the state of the art in correspondence of the corn rs f th annular m tallic cor which quite frequently ar the cause of th destruction f the bead due t rupturing of the cords r lac rations of th enc mpassing comp und.

Claims

1. A bead reinforc m nt comprising an annular circumf rentially inextensible bead core

completely enclosed in lastomeric material of which the material constituting the outer surface has a vulcanising speed less than that of any other elastomeric material incorporated in the bead reinforcement.

2. A bead reinforcement according to Claim 1 wherein said core is constituted by a plurality of adjacent cords of metallic wire having in cross-section a form that is substantially hexagonal with the radially innermost side inclined at about 15° with respect to the axis of said reinforcement.

3. A bead reinforcement according to Claim 1 or Claim 2 comprising a first compacting layer made of a first elastomeric compound in contact with the core and a second covering layer made of a second elastomeric compound which completely encloses the said first layer, the vulcanising speed of said second compound having a lesser value than that of said first compound.

4. A bead reinforcement according to Claim 3 wherein said second layer comprises a rubberised cord fabric reinforced with longitudinally extending cords of a material which shrinks due to the effects of heat.

5. A bead reinforcement according to Claim 4 wherein said fabric is wound spirally over said first layer along the entire circumferential development of the bead reinforcement.

6. A bead reinforcement according to any one of Claims 3, 4 or 5 wherein a filler having a lenticular shape and made of a third compound is inserted between said first and second layers.

7. A bead reinforcement according to Claim 6 wherein the vulcanising speed of said third compound is substantially equal to that of said first compound.

8. A bead reinforcement according to any one of Claims 3 to 7 wherein said second covering layer is enclosed by a third layer comprising a sheet of material made of a fourth elastomeric compound the vulcanising speed of which is less than that f said second compound.

9. A bead reinforc ment according to Claim 8 wher in said f urth compound, when subjected to a thermal treatment at a temperature of not less than 120°C for at least 15 minutes reaches a degree of vulcanisation defined by means of the variation curve of the elastic modulus of not greater than 15%.

10. A bead reinforcement according to Claim 9 wherein said degree of vulcanisation is not greater than 10%.

11. A bead reinforcement according to any one of Claims 3 to 10, wherein said first compound when subjected to a thermal treatment at a temperature of not more than 120°C for not more than 15 minutes reaches a degree of vulcanisation defined by means of the variation curve of the elastomeric modulus of not less than 20%.

12. A bead reinforcement according to Claim 11 wherein said degree of vulcanisation is not less than 30%.

13. A bead reinforcement according to any one of Claims 3 to 12 wherein the minimum thickness of said first layer is comprised between 1.5 and 2 mm.

14. A bead reinforcement according to any one of Claims 8 to 13 wherein the thickness of said sheet of a fourth compound is comprised between 0.5 and 0.8 mm.

15. A bead reinforcement substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

16. A tyre bead incorporating a bead reinforcement according to any one of the preceding claims.

17. A tyre bead substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.

18. A tyre incorporating a tyre bead according to Claim 16 or Claim 17.

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